Space Weather Technical Forecast

Issued on Tuesday 17 December 2024 at 01:30 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of G1/Minor Geomagnetic Storms on Day 1 (17 Dec). Increasing risk of M-flares or greater in the coming days.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low, with a peak C4.5 flare registered at 16/0732 UTC from Ex-AR3917, beyond the western limb. There are five sunspot regions on the Earth-facing disc. AR3924 (Ehi/Beta-Gamma) remains the most complex sunspot group on the disc, with minor growth of its main lead and trailing spots, but the region was largely inactive. AR3920 (Cso/Beta) saw decay in its leading spots, whilst maintaining a mature trailing region. AR3922 (Dai/Beta) was the most developmental on the disc with emergence of spots in all parts of the group. Despite this the region appears stable. The remaining regions on the disc were largely unchanged through the period.

No new Earth-directed CMEs were in evidence in available imagery.

Solar Wind / Geomagnetic Activity: Solar winds, as reported by ACE and DSCOVR at L1, showed a general slowing from slightly elevated to slow-ambient as the connection to the HSS from CH99+ gradually declined. However, there is evidence to suggest that a minor CME arrived at L1 after 16/1800 UTC, with a minor enhancement in solar wind parameters. Speeds peaked at 440km/s at 16/0336 UTC, before falling to around 390km/s by the end of the period. Density was generally around average, but predominantly above average until approximately 16/0630 UTC. The Interplanetary Magnetic Field (IMF), Bt, was initially moderate peaking at 10nT, before becoming predominantly weak from 16/0630 UTC. The north-south component, Bz, oscillated between positive and negative, but generally favoured a weakly negative direction. Over the entire period it varied between +7/-7nT. The phi angle was generally positive (away from the Sun). The net result of the above solar wind measures was for mainly Quiet to Unsettled geomagnetic activity, but with an Active (Kp4) interval from 16/2100-2400 UTC.

Energetic Particles / Solar Radiation: High energy proton flux observed by GOES18 was at background levels, though a minor enhancement in 10MeV levels was indicated in available data after 16/1800 UTC. High energy electron flux (greater than 2MeV) observed by GOES16 was background. The associated 24-hour fluence was well below the Active (1e8 integrated flux) threshold. The 17/0000 UTC observation was 1.28e6 integrated pfu.

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Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate Solar activity is forecast with a chance of M-class flares on Day 1 (17 Dec), increasing to become likely from Day 2 (18 Dec) onwards. There is a daily, albeit very slight chance of isolated X-class flares.

Solar Wind / Geomagnetic Activity: A rather slow CME that left the Sun on 15 Dec is expected to give Earth a glancing impact on either Day 2 or 3 (18 or 19 Dec). Several other CMEs that left the Sun in the past few days are forecast as near misses, but cannot be completely ruled out as flanking arrivals at Earth before the end of Day 3 (19 Dec). Otherwise a declining connection to the high-speed stream of CH99 is expected to see solar wind speeds ease to persistently background levels on Day 1 (17 Dec). No further coronal hole enhancements are anticipated through the remainder of the forecast period.

Geomagnetic activity is expected to be generally Unsettled on Day 1 (17 Dec), but with Active intervals likely and a chance of G1/Minor Storm conditions, especially at first, due to high-speed stream and/or CME influence. Between Days 2 and 3 (18-19 Dec) activity is likely to peak at Unsettled to Active levels following the forecast arrival of a glancing CME, with a slight chance of G1/Minor Storms occurring. Activity should return to Quiet to Unsettled levels by Day 4 (20 Dec).

Energetic Particles / Solar Radiation: High energy proton flux is expected to remain at background, but carries a daily, slight chance of reaching S1/Minor Storm levels or greater, in response to any notable solar flares. High energy electron flux is expected to be at background to moderate levels. The 24-hour fluence is expected to remain below the Active threshold throughout.

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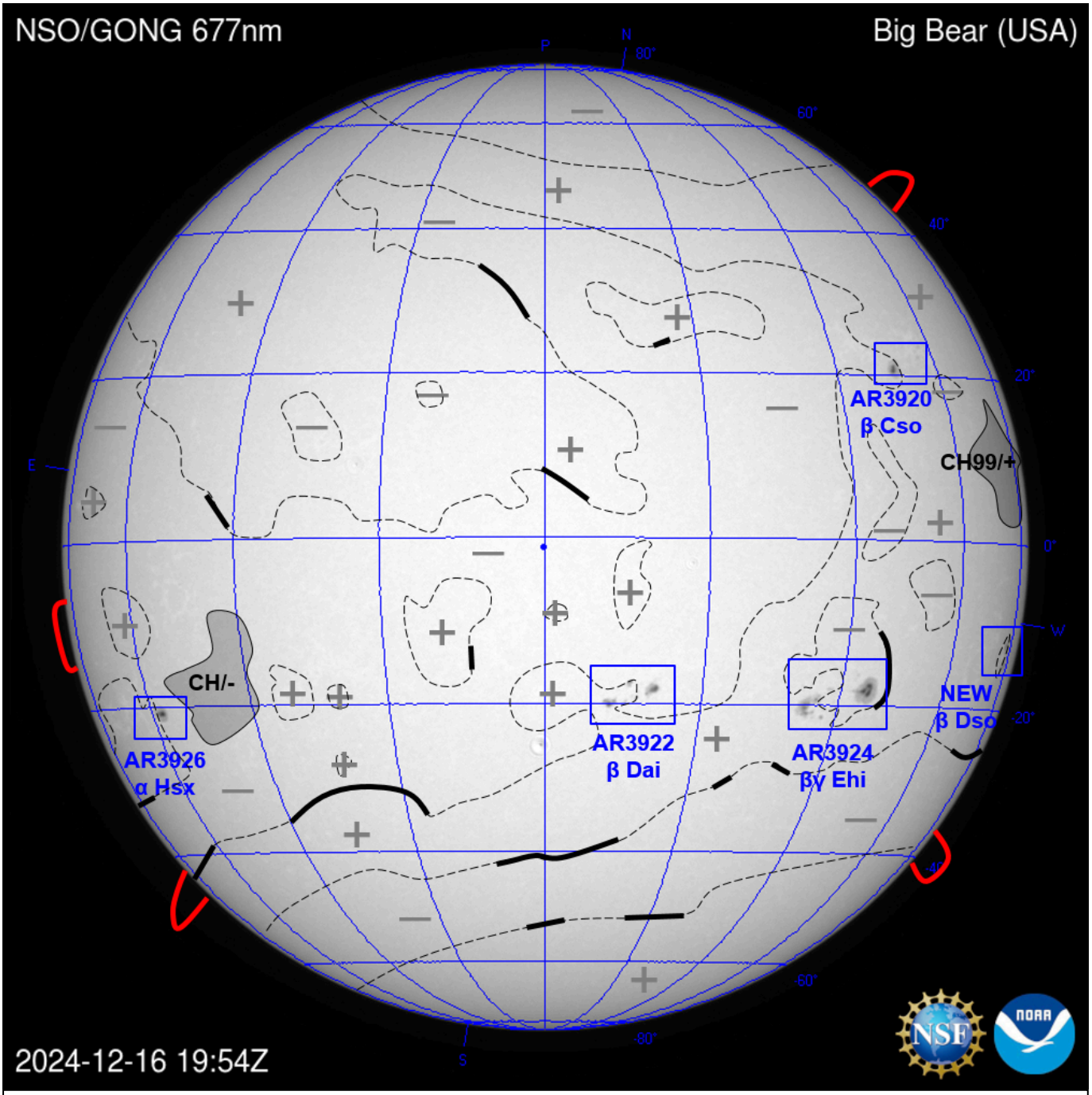
Figure 1: MOSWOC Solar Synoptic Map valid 15/2000 UTC



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

A CME associated with a large filament eruption in the southwest disc late 14 Dec is expected to pass mostly ahead and below Earth's orbit, but brings a chance of a glancing impact late Day 1 (17 Dec) or early Day 2 (18 Dec). This event was shortly followed by a potentially more significant filament eruption around 15/0400 UTC from a region to the southeast of AR3924. Some coronal dimming was evident in GOES SUVI-195 imagery and a fairly slow, faint 'partial halo' CME was indicated in STEREO A COR 2 imagery and to a lesser degree in LASCO C2/C3 imagery. This looks to again largely pass ahead of Earth's orbit, but likely gives a glancing impact at Earth late on Day 2 (18 Dec), or possibly early Day 3 (19 Dec). Confidence in arrival timings and predicted geomagnetic indices from this feature are low, given the difficulty in CME analysis and fit. Additionally, a number of minor CMEs in the past several days have been modelled as near-misses, but due to ongoing imagery gaps and sheer number of events, further transient CMEs cannot be ruled out during the forecast period.

The coronal hole-based forecast carries much higher confidence. Connection to CH99+, which brought slightly elevated wind speeds in the past couple of days appears to be waning with solar wind speeds now at background levels. No further coronal hole enhancements are anticipated through the remainder of the forecast period. MOSWOC ENLIL output maintains higher wind speeds than currently observed by around 50km/s. Furthermore, a stronger enhancement indicated between Days 1-3 (17-19 Dec) has no observable source region currently on the visible disc. This is consequently considered anomalous and disregarded at this stage. The results of this erroneous elevated wind speed may result in any CME material being shown to arrive too early in MOSWOC ENLIL.

Geomagnetic activity is expected to be generally Unsettled on Day 1 (17 Dec), but with Active intervals likely and a chance of G1/Minor Storm conditions, especially at first, due to high-speed stream and/or CME influence. Between Days 2 and 3 (18-19 Dec) activity is likely to peak at Unsettled to Active levels following the forecast arrival of a glancing CME, with a slight chance of G1/Minor Storms occurring. Activity should return to Quiet to Unsettled levels by Day 4 (20 Dec).

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	40	20	10	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R⊙ (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed (km/s)	Estimated Arrival Time (UTC)	Comments
2024-12-15 10:43	Partial	Filament	SW	481	18/1900 UTC	Low confidence in arrival time and predicted geomagnetic indices due to difficulty in CME analysis and fit.

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Figure 2: ACE EPAM Protons rising significantly, potentially signifying the precursor of a CME impact.

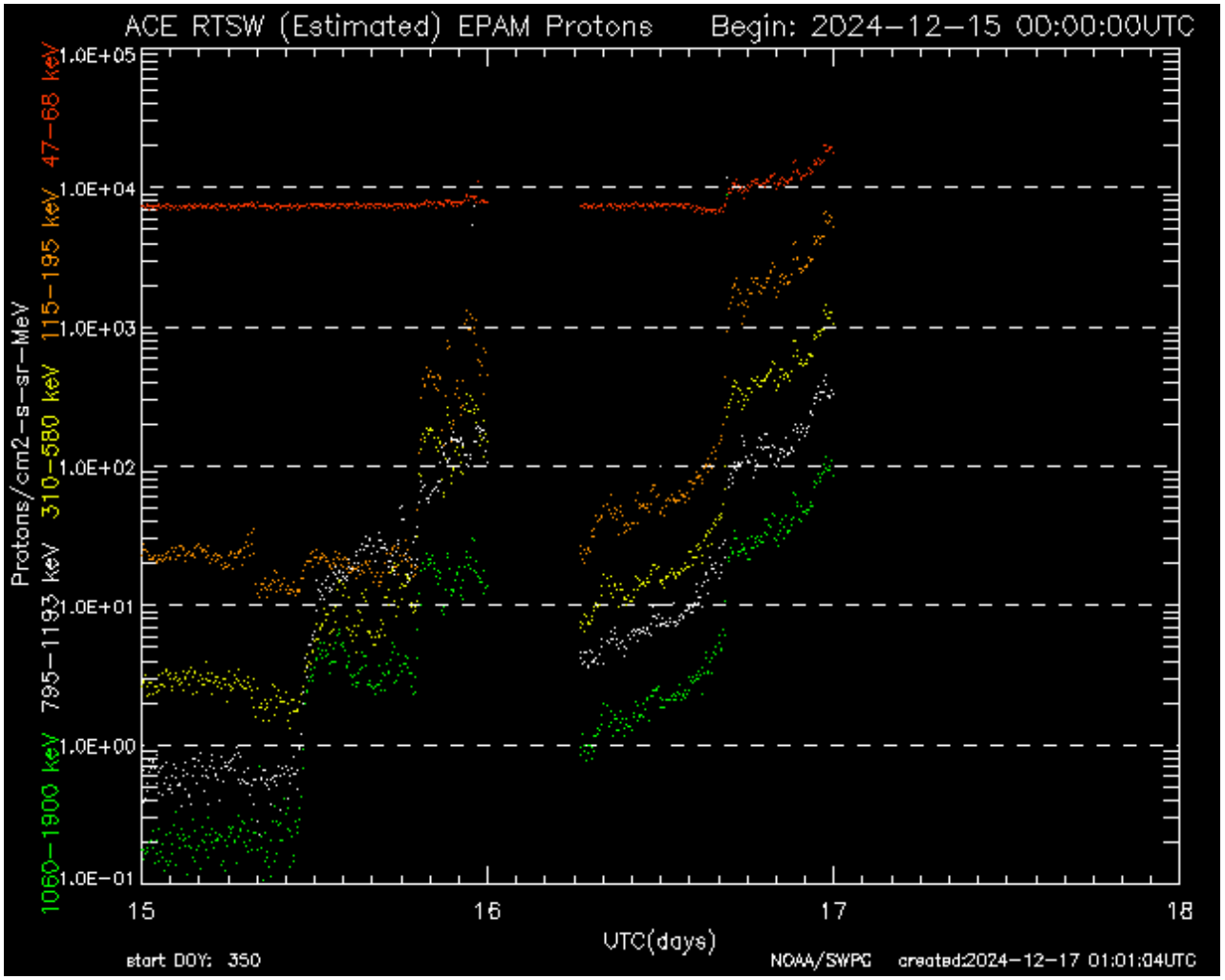

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Figure 3: Latest MOSWOC ENLIL output for 18/1900 UTC, estimated arrival time of CME from early 15 Dec.

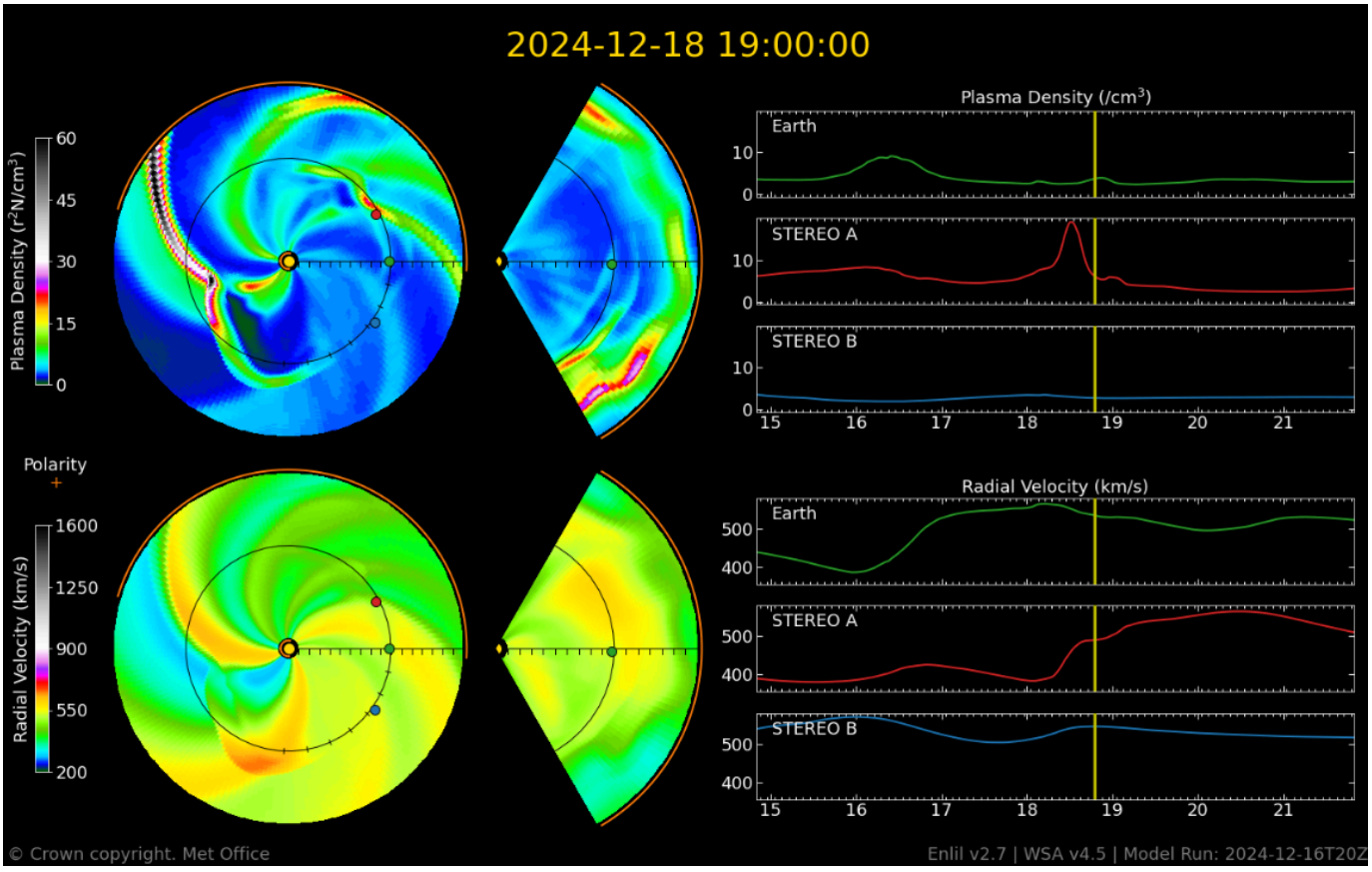
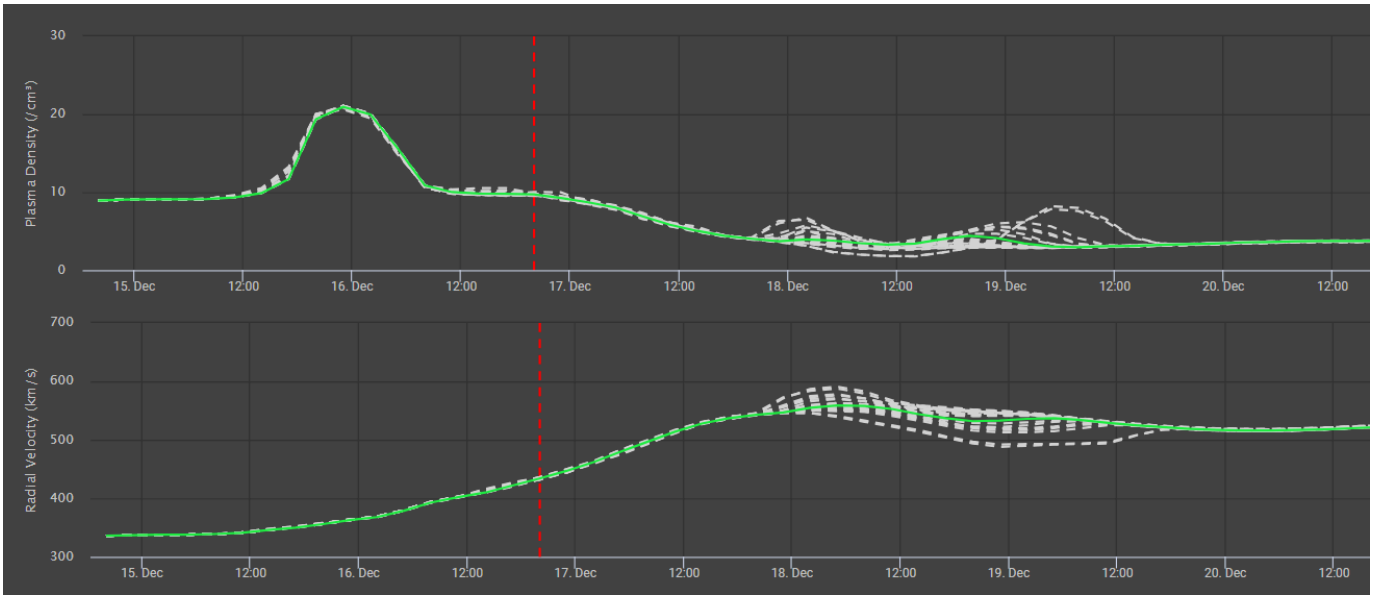


Figure 4: MOSWOC Enlil Ensemble forecast. Speeds reaching in excess of 500km/s in the coming days are considered erroneous, given a clear lack of a source region on the facing-disc.



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Radio Blackouts - X-Ray Flares

Solar activity has returned to Low levels, with a peak C4.5 flare registered at 16/0732 UTC from Ex-AR3917, beyond the western limb. There are currently five sunspot regions on the Earth-facing disc. AR3924 in the southwest is the most complex region and consists of a large, symmetrical leading spot and a smaller, but irregularly shaped trailing spot. Several smaller intermediate spots persist, though these evolve only slowly. AR3920 provided the most recent M-class flare on 15 Dec, but has since shown signs of decay, especially in its leading region. AR3922 in the southwest is the most developmental group on the disc. It continues to show signs of growth with emergence of spots in all parts of the group. Despite this the region remains largely stable. The remaining sunspot groups on the disc are smaller and more magnetically simple.

There continues to be the likelihood for further regions to rotate onto the disc from over the east limb between Days 1-3 (17-19 Dec) corresponding to Ex-AR3902, Ex-AR3905 and Ex-AR3906. The latter two produced M-class flares when they were last on the facing-disc and recent far-sided CME activity and helio-seismic soundings suggest that at least one of these regions remains active.

Low to Moderate Solar activity is forecast with a chance of M-class flares on Day 1 (17 Dec), increasing to become likely from Day 2 (18 Dec) onwards. There is a daily, albeit very slight chance of isolated X-class flares.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	No	50	55	60	60
Very Active	R3-R5 (X Class)	No	5	5	10	10

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Solar Radiation Storms (High Energy Protons)

GOES18 proton flux is at background levels but carries a daily, slight chance of reaching S1/Minor Storm levels or greater, in response to any notable solar flares. Proton enhancements are most likely from AR3924. This region will rotate over the western horizon on Day 4 (19 Dec), but Proton storm probabilities are maintained for at least 24-hours after it leaves the visible disc.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	15	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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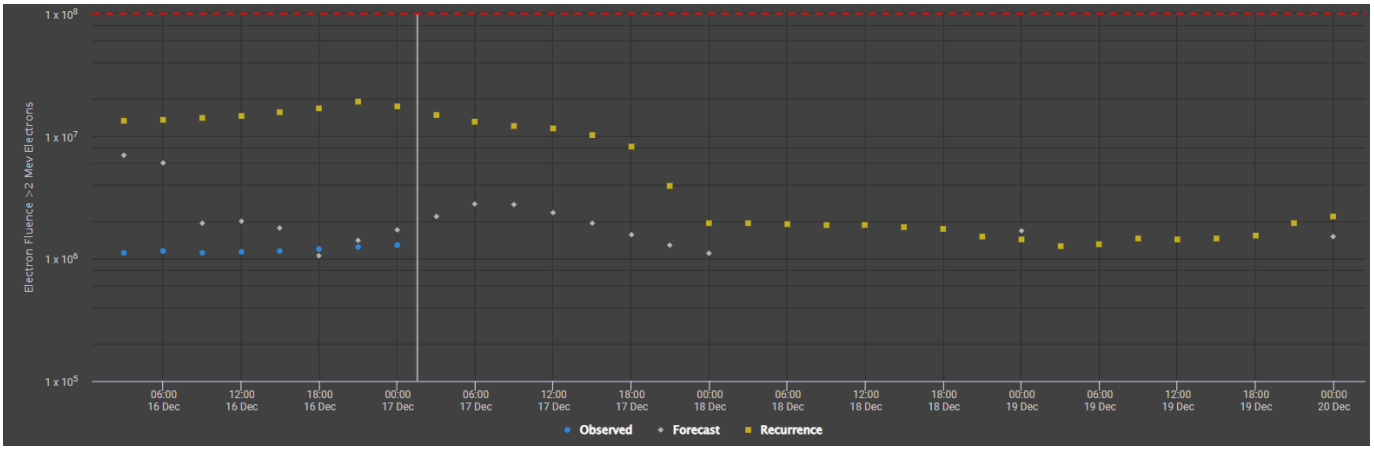
High Energy Electrons (≥ 2MeV)

High energy electron flux observed by GOES16 has been at background levels following the influence of the HSS from CH99+ in compressing the orbit of the Van Allen Radiation Belts. Electron flux may see moderate peaks in the diurnal cycle during in the coming days as the Van Allen belts return to more typical orbits, but could again be be temporarily reduced given the potential for one or more minor CME arrivals during the forecast period.

The associated 24-hour fluence is well below the Active (1e8 integrated flux) threshold and expected to remain below this throughout the forecast period. MOSWOC REFM output is considered to be providing good guidance.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	1	1	1	1
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

Figure 5: Latest MOSWOC REFM forecast and Recurrence.



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